SEAFRAME

Winter 2006 • Volume 2 • Issue 1 *Ships & Ship Systems Quarterly Publication*

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **2006**	2. REPORT TYPE	3. DATES COVERED **00-00-2006 to 00-00-2006**

4. TITLE AND SUBTITLE **SeaFrame. Volume 2, Issue 1, Winter 2006**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Surface Warfare Center, Carderock Division,Code 3443,9500 MacArthur Blvd,West Bethesda,MD,20817-5700**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S)
	11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

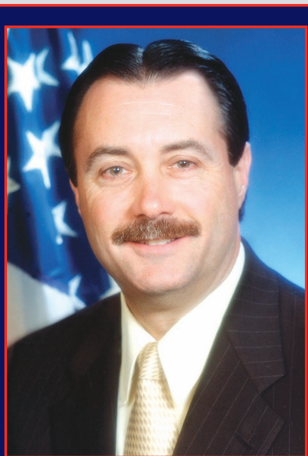
14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**28**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

SEAFRAME
Ships & Ship Systems Quarterly Publication



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Working Toward Efficiency and Effectiveness in Ships and Ship Systems

Ships & Ship Systems NotePAD

By Charles (Randy) Reeves

A primary responsibility of each product area director (PAD) is to increase efficiency and effectiveness in the product area (PA). The NAVSEA Warfare Center concept of operations lays out this PAD role as follows: "within their product area, [the product area directors] work across the Warfare Center enterprise to identify and eliminate inefficiencies and redundancies … and maintain an intense interest in the efficient and effective management of capabilities across sites."

In the Ships and Ship Systems (S^3) PA, a focus on efficiency and effectiveness is being woven into all aspects of our work. A good example of where we've taken a step in this area and will save the Navy money can be found in our Signatures, Silencing Systems, and Susceptibility Core Equity. We are eliminating the *USNS Hayes*, a signature measurements test platform for submarines based in Cape Canaveral, FL. This specialized ship, run by the Naval Surface Warfare Center, Carderock Division, featured an array of hydrophone sensors used to gather sound from passing craft. Instead, that capability will be transitioned to a fixed measurement site installed at the Naval Undersea Warfare Center's Atlantic Undersea Test and Evaluation Center (AUTEC). This new measurement facility will feature three-dimensional tracking, performance measurement, and data collection resources in a single location. With this initiative, we estimate that performing submarine trials for the U.S. Navy will cost $4 million less per year.

Other initiatives include:

Lean Six Sigma—This is a continuous improvement process. The S^3 PA is benefiting from the efforts of this NAVSEA-led initiative. Across the product area, efforts are underway to find the most effective and efficient processes to provide our customers with what they need. Lean is the focus of this issue's Business article. See page 2 for more information.

Management Operating System (MOS)—The S^3 PA is benefiting from the NAVSEA-led business improvement efforts. Carderock Division, which makes up a significant portion of the S^3 PA, is piloting MOS, a business tool, which documents employee action items and work activities weekly and captures organizational operating data and performance.

Technical Health Assessment—This tool, developed for the S^3 PA, is being used to understand the capability (knowledge) and capacity (workload) required to sustain the product area. Using the Technical Health Assessment, we've analyzed the extent and health of our core equities, technical capabilities, knowledge areas, and facilities that comprise the S^3 PA. Having assessed the health of those areas, and their linkage to our strategic plan, we are now examining what hiring and investments are needed to support future demands, as well as what areas should be drawn down or considered for divestment.

Customer Advocates—The S^3 PA established a virtual organization of customer advocates to serve as functional agents of the PADs. Their role is to interface with customers to develop a unified customer support approach that brings together efficient and effective combinations of technical capabilities that span multiple divisions. This issue of SEAFRAME carries an article on the Joint Services Program Customer Advocates. See page 12.

Many of these initiatives were originated within the last year. We've experienced a dramatic shift in our focus on becoming efficient and effective using these and other tools to help us focus our efforts. As we move forward and we refine and standardize our practices across the S^3 PA, we expect to see even greater success in meeting our customers' needs in the most concise and cost-effective way.

C R Reeves

SEAFRAME

Ships & Ship Systems Quarterly Publication

Winter 2006 • Volume 2 • Issue 1

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SEAFRAME is the official publication of the S^3 Product Area. It is published quarterly with appropriated funds in accordance with NAVSO-P35. Any views and opinions expressed are not necessarily those of the Department of the Navy.

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The SEAFRAME staff reserves the right to edit or rewrite all submissions.

On the Cover: The ship and craft images illustrate the variety of joint service programs and customers supported by the Ships & Ship Systems Product Area. See feature story on Joint Programs on page 12.
Images provided by Combatant Craft Division
Cover design by Gloria Patterson.

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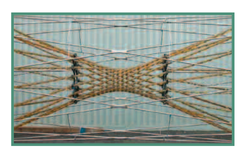
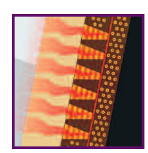


TECHNOLOGY AND INNOVATION



Improving Efficiency and Effectiveness

Using the LEAN Six Sigma Process to Find the Best Business Practices in Ships and Ship Systems

By Leslie Spaulding

Vice Admiral Paul Sullivan, Commander, Naval Sea Systems Command, places great emphasis on implementing Lean Six Sigma, calling it a command priority. In a September 2005 memo laying out his guidance for the second year of the NAVSEA Lean effort, he wrote, "Lean Six Sigma implementation is an essential contributor to the mission of our NAVSEA/PEO team to deliver safe, reliable, and affordable naval ships and weapons systems to meet current and future Fleet readiness."

The guidance also identified areas in the process needing improvement. One such area involved identifying the savings and allowing the customers to decide how to reapply those savings. "We have an absolute responsibility to lower the cost of doing business and articulate where in the funding flow savings can be harvested in today's budgets," he wrote. "[The customers] will decide what to do with the cost reductions achieved in the execution year, budget year, and POM (program objective memorandum) years. NAVSEA's job is to lower the cost of doing business

Examples of successes include:

- Engineers within the Machinery Systems Core Equity (CE) in Philadelphia used the Lean methodology to examine their support of the Marine Gas Turbine Program. This program cost the Navy $77M in FY 05, so looking for efficiency was paramount. The MGT Program includes program management, engineering, and the repair and overhaul of the 1,100 Navy gas turbine engines. Overall, the planned streamlining of work processes identified during the initial value stream analysis (VSA) should yield a 6% efficiency improvement for the Navy and is projected to reduce cost by as much as 10% or $6.5 million in FY 07.

- Another effort accomplished within the Machinery Systems CE in Philadelphia involved reviewing the way alteration kits are handled. Using Lean principles, inventory was reduced by $13 million, key individuals were redeployed to other critical processes, and a standard process was created to determine the need and rationale for future inventory.

- Under the Signatures, Silencing Systems, and Susceptibility CE engineers in Bayview, ID, performed a VSA on their Large Scale Vehicle (LSV)/Intermediate Scale Measurement System experimental trials support. Through Lean methodology, they effectively fused two separate workforces into one, gaining an estimated three-year savings of approximately $1.5 million.

- Recently, engineers from the Ship Signatures Department at Carderock performed a VSA of an entire 480-employee department. A management team reviewed all R&D, T&E, and administrative functions associated with improving and maintaining submarine and surface ship acoustic, electromagnetic, infrared, radar cross section, and magnetic signatures. Nineteen potential rapid improvement events (RIEs) were identified, of which six will be performed in FY 06, with a potential savings of $500K in FY 06.

- Vulnerability and Survivability CE engineers and scientists performed a VSA of their ship survivability efforts. Annually, the dollar value of this value stream varies widely but is expected to exceed $20 million in FY 06 and 07. The team mapped out the current and ideal states for program management, modeling and simulation, technical authority support, science and technology development, consulting and training, and tests and trials. Seven key RIEs were identified, with four to be performed in FY 06.

- Engineers who support the Machinery Systems CE in Port Hueneme realized a 33% reduction in civilian labor and travel supporting coupling pullers in the underway replenishment systems in-service engineering value stream. Port Hueneme Division now uses the coupling pullers to perform repairs on three types of UNREP hydraulic transmissions. With a cost of just $2,000, the Navy realized a savings in FY 05 of $218,000.

by implementing process efficiencies and identifying these successes to the requirements and resource owners."

Sullivan also emphasized the need for senior managers to embrace Lean, to complete a Lean Champion course, and to participate in Lean events. Under the Ships and Ship Systems (S^3) Product Area (PA), C. Randy Reeves, the PA Director, is committed to identifying value streams that impact ships and ship systems at the product area level. Carderock Division appointed Craig Alig and John Sofia as Lean champions. As the S^3 work is predominately conducted at Carderock Division, Alig and Sofia will be invaluable to the S^3 PA's Lean initiatives, as will be the Lean champions at other Warfare Center Divisions. Throughout the product area, Lean initiatives have been underway for approximately one year.

"Lean is a continuous improvement process that requires long-term cultural change," said Reeves. "Leadership at all levels needs to understand and adopt it. As we move forward, we will be looking for ideas for areas within the S^3 PA that require improvement, as well as feedback from our customers."

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Ship Integration & Design

Ship Acquisition Cost Estimation

Cost Analysis Supports More Efficient Pre-Construction Planning

By William Palmer

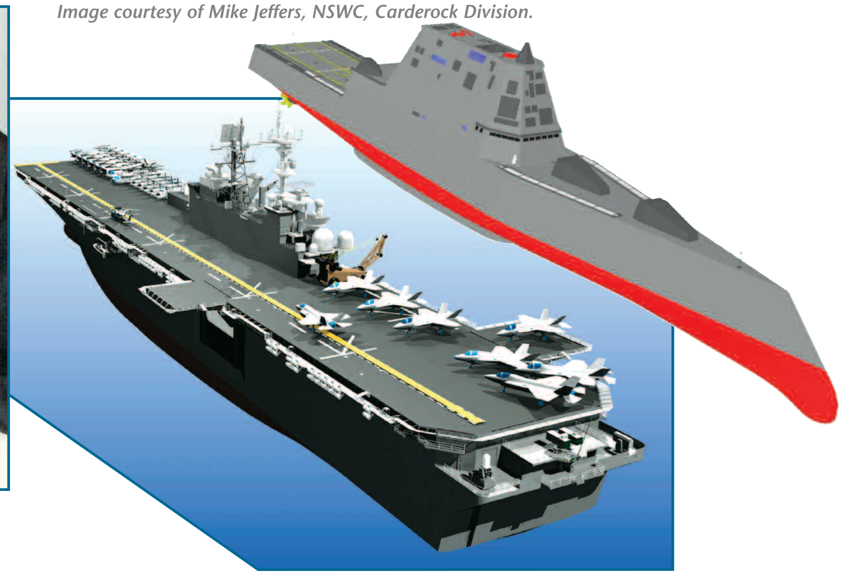
Cost estimation occurs at all cycles of a shipbuilding project, and is one of the first actions to take place long before the keel is laid for a new construction vessel. Cost analysts from the Naval Surface Warfare Center, Carderock Division, support many of the Navy's large shipbuilding programs. Two such examples are the DD(X) and the LHA Replacement (LHA(R)) programs. The DD(X) was begun in 1995, and recently reached its Milestone B timeframe, in which commitment is made to construct the ship. The LHA(R) project, a modified repeat of the LHD 8 shipbuilding program, constitutes a significant change in amphibious assault ship design, as it will be heavily focused on

COST ESTIMATE (Continued on page 4)

COST ESTIMATE (Continued from page 3)

From left, Jim Snyder, NAVSEA 017; RADM Charles Hamilton, PEO Ships; Jeff Wolfe, NSWCCD 2110, discuss an LHA(R) program life-cycle cost brief.
Photo by Lamarr Jackson, BAE Systems, WNY Multi-Media Group.

Conceptual drawing of DD(X).
Image courtesy of Mike Jeffers, NSWC, Carderock Division.



Artist's conception of LHA(R).
Image courtesy of Jeff Wolfe, NSWC, Carderock Division.

aviation operations, providing additional hangar space and accommodating MV-22 Ospreys and F35B Joint Strike Fighters.

Both programs recently reached their Milestone B event, where resources are committed to fully design and construct the first-of-class vessel. Before Milestone B, an extremely important design phase called the analysis of alternatives (AOA) is executed. When the AOA is started, approval has been given to explore concepts involving new design features, weapons systems, materials and/or propulsion system enhancements.

During the AOA, a broad perspective is established, and a basic description of the ship is assembled. Concepts are largely the order of the day, and the cost estimate is based on the ideas at hand when the concept is set down on paper. A foundational idea at this point, and continuing throughout the design cycle, is to balance capabilities against cost. Ship designers experience budget problems due to requirements growth–again, balancing per-ship cost and the number of ships to populate a class against the budget available to build those ships, and this is a major challenge in the shipbuilding arena.

As part of the Planning and Programming Budgeting System of the Department of Defense, a period of six years before construction is also critical, because, at that time, a budget estimate is submitted. If approved, the budget becomes part of the Navy's overall budget. If budgetary changes need to be made, it is quite an elaborate process to implement those changes.

Once Milestone B is achieved, a critical design review has been completed, and the design is at a sufficient state of maturity such that moving from concept to physical reality can proceed. A set of specifications is agreed upon, and a detailed design of the ship is created. The NAVSEA Technical Authority (TA) for Ships is involved at this point, and steps taken here are done to convince the TA that there are no "show-stoppers" in the ship's design, and that construction can proceed without major holdups. The cost model is the next critical budgetary task that keeps track of changing costs. Labor costs, materials as a function of ship characterization, even the ship weight report from the overall ship design are all important inputs to the cost model. When various factors such as the Navy's shipbuilding plan, ship design, acquisition strategy, labor rates, and shipyard overhead rates change, the cost estimates also need to be updated and revised. A learning curve is in progress, and traceability back to data sources is being built into this budget monitoring system.

A Lean initiative was recently started to adopt a common cost model that could be applied across all major NAVSEA programs, incorporating necessary features for each program. In shipbuilding, there are many changes and technological advances that can take place, and cost analysis must create new methodologies or adapt existing methodologies to estimate the cost of these changes. Inside of this new model are cost estimating relationships (CERs), a product which inputs to the model. Each type of ship and each shipyard has a different set of CERs to accommodate design differences and business

variables. Keeping this model healthy as a cost estimation tool involves an entire group of budget planners to keep it viable.

Cost estimation is integral to the Ships and Ship Systems Product Area and reaches across a broad spectrum of ship acquisition and engineering efforts, bringing together under one function several different business and technical enterprises.

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HULL FORMS & PROPULSORS

LCC DRAG REDUCTION EXPERIMENTS

Researchers Seek to Improve Hull Form Efficiency through Frictional Drag Reduction

By William Palmer

The Large Cavitation Channel (LCC) in Memphis, TN, was recently the site of ongoing experiments to establish the effectiveness of high molecular weight polymers in reducing frictional drag between a ship's hull and the water flow. In a work for private parties agreement between the Navy and the University of Michigan, researchers are collaborating under Defense Advanced Research Projects Agency (DARPA) and Office of Naval Research (ONR) sponsorship to establish a database of information and data on the findings of their drag reduction experiments. This database will also assist in computational fluid dynamics (CFD) validation and improvement. The LCC is a facility owned by the Naval Surface Warfare Center, Carderock Division, and operated to support research and experimentation identified in part by the Hull Forms and

DRAG REDUCTION (Continued on page 6)

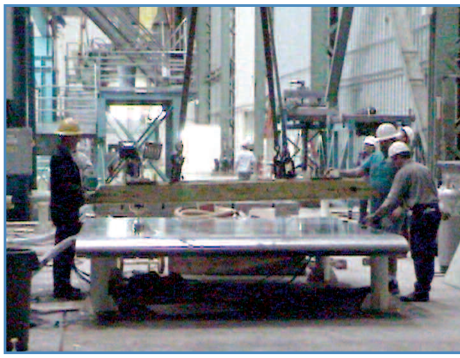
DRAG REDUCTION *(Continued from page 5)*

Propulsors Core Equity of the Ships and Ship Systems (S^3) Product Area (PA).

Using a 10-foot-wide, 40-foot-long stainless steel plate mounted in the experiment test section of the LCC, a controlled boundary layer flow can be created and studied in a remarkably efficient and effective manner, unmatched by any previous drag reduction data set. This test plate was previously used to examine drag reduction by means of the injection of small air bubbles (microbubbles) through slots across the test plate. Shear-stress sensors quantified frictional drag reduction within the boundary layer between the plate and the water. This is where reduction in drag must occur. The LCC can control the flow speed of the water over the plate, and flow speeds during these drag reduction tests ranged to 20 meters per second, approaching 40 knots.

Using the same large stainless plate apparatus, personnel evaluated drag reduction through the injection of polymers. Polymer molecules were treated with a dye to visualize their dispersion. A characteristic of the dye is that it fluoresces when exposed to laser light. When polymers with the dye were introduced into the flow above the plate, laser light illuminated the polymers, providing a visual record of polymer concentration and dispersion. A progressive cavity pump moved the polymers through manifolds and out of the injection slots to avoid breaking down the long polymer molecular chains responsible for the drag-reducing characteristic. A range of molecular weights, injection rates, and differing concentrations were used in the research. Dispersion patterns were recorded for flow speeds varying from 6 to 20 meters per second. Persistence, a measure of how fast the microbubbles or polymers lose their drag-reducing capability, was one important characteristic that could be efficiently evaluated by having the long test apparatus and high flow velocities produce conditions much like the flow over a prototype ship hull. Generally, polymers fared better than microbubbles, staying in the boundary layer longer, thus affecting drag reduction for a longer period of time or axial extent from the injection site. Details of the polymer interaction with the turbulent flow were additionally examined using particle imaging velocimetry (PIV) systems installed within the test plate.

The LCC contains 1.4 million gallons of water. Even with this large volume, when the polymers start to build up in the closed-loop system, an undesirable source of background contamination results, necessitating a periodic procedure to remove the polymers. In a typical testing schedule, the polymers were mixed and stored on Saturday and Sunday. Monday through Thursday involved taking data, and on Friday the entire LCC volume was drained and refilled with clean water. This sequence was repeated for several weeks.



LCC technicians prepare drag reduction experiment plate for insertion into the test section of the Large Cavitation Channel.

The instrumented drag reduction plate is lowered by overhead crane into the Large Cavitation Channel.

LCC technicians angle a 5-ton section of the drag reduction experimental plate into the test section of the Large Cavitation Channel.

Riggers finalize horizontal positioning of the forward section of the drag reduction test plate.

Images courtesy of Robert A. Reiss, NSWC, Carderock Division.

In Fall 2005, data from the previous testing were analyzed. Another round of tests using microbubbles was completed in February. Further tests with both polymers and microbubbles may occur later in 2006. The goal of frictional drag reduction on ships is to allow higher speeds, lower power levels, and improve fuel efficiency.

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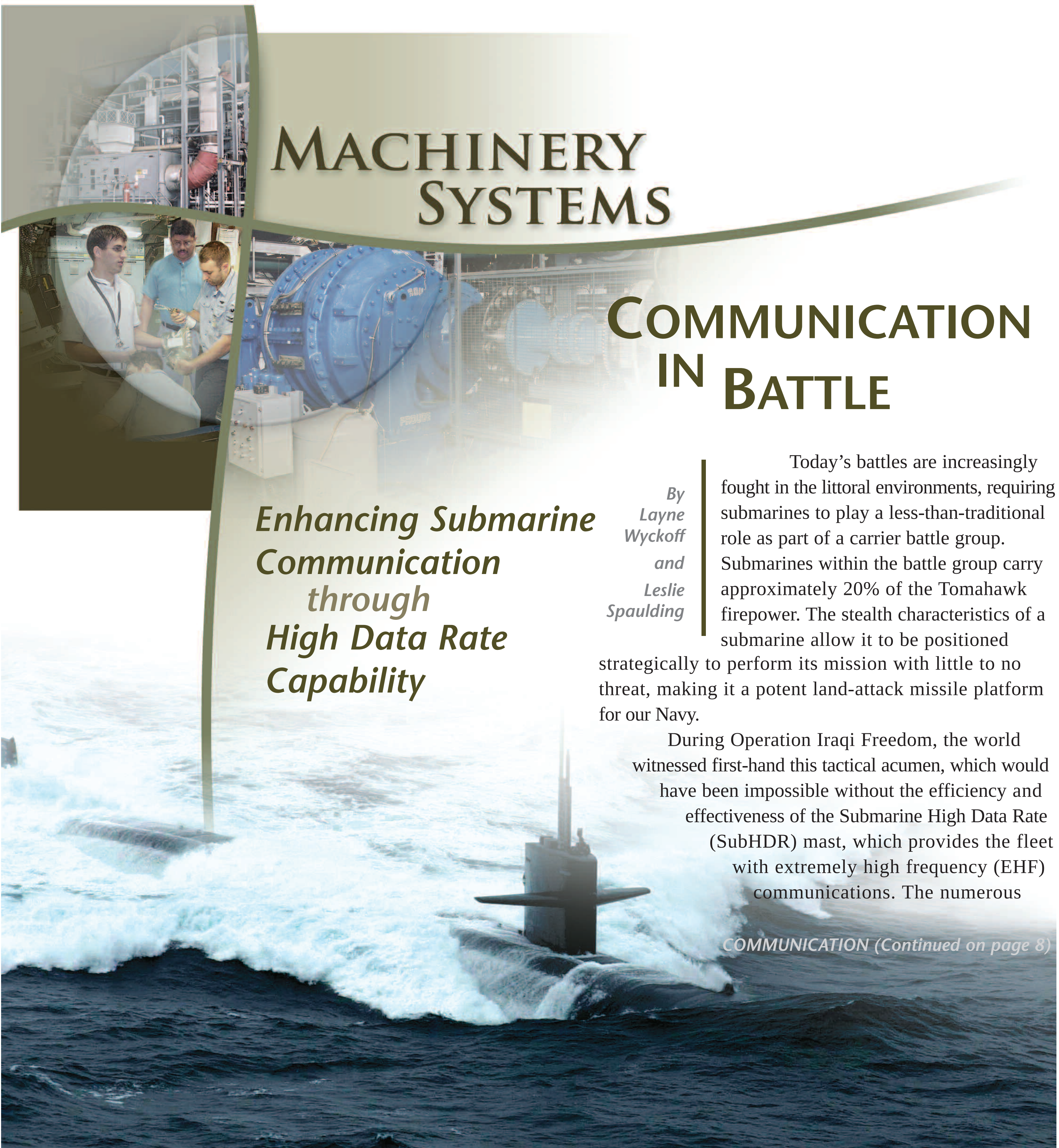
MACHINERY SYSTEMS



COMMUNICATION IN BATTLE

Enhancing Submarine Communication through High Data Rate Capability

By Layne Wyckoff and Leslie Spaulding

Today's battles are increasingly fought in the littoral environments, requiring submarines to play a less-than-traditional role as part of a carrier battle group. Submarines within the battle group carry approximately 20% of the Tomahawk firepower. The stealth characteristics of a submarine allow it to be positioned strategically to perform its mission with little to no threat, making it a potent land-attack missile platform for our Navy.

During Operation Iraqi Freedom, the world witnessed first-hand this tactical acumen, which would have been impossible without the efficiency and effectiveness of the Submarine High Data Rate (SubHDR) mast, which provides the fleet with extremely high frequency (EHF) communications. The numerous

COMMUNICATION (Continued on page 8)

COMMUNICATION (Continued from page 7)

Above, Portsmouth Naval Shipyard riggers lift the SubHDR faired mast assembly to the ***USS Providence*** (SSN 719) using the newly developed faired mast lifting stops. The lifting stops and specialized fairing inserts provide a much safer and easier lift.

At right, the SubHDR antenna mast system fully raised on the ***USS Honolulu*** in Pearl Harbor, HI.
Photos provided by Layne Wyckoff, NSWC, Carderock Division.

Tomahawk cruise missiles launched by the *Los Angeles* (SSN 688) Class fast attack submarine force was enabled by the SubHDR system. In a July 2003 Sea Power article, titled “Sub Director Foresees ‘Revolutionary’ Power of SSGNs,” Vice Admiral Paul F. Sullivan, who is now Commander, Naval Sea Systems Command, wrote, “There is a very good news story that developed during the recent Iraqi Freedom Operation. We had 12 U.S. submarines [in theater], and we had two of the British submarines that launched Tomahawks. Of the 800 or so Tomahawk missiles that were shot, about a third of them were fired by those 14 ships. What really intrigued me watching this as a research sponsor was the ability of the High Data Rate antenna. All but one of our ships had that. It is a wideband antenna that allows you to be on the net and have the bandwidth to pass a lot of information.” At the time, Sullivan was the Deputy Commander for Ship Design, Integration, and Engineering.

A top-priority command, control, communications, computers, and intelligence (C4I) initiative, the SubHDR mast is the Navy’s first satellite communication multi-band dish antenna system. It enables the submarine fleet to access a variety of systems, including the secure, survivable EHF Joint-MILSTAR Satellite Program. It also provides access to the Defense Satellite Communication System (DSCS) in the super high frequency (SHF) band, and the Global Broadcast Service (GBS) will eventually be upgraded to allow the use of Internet Protocols, providing the capability to receive time-critical tactical information. Future improvements and capability enhancement aside, the transfer of high-resolution color images as well as streaming video on the SubHDR antenna are received/ transmitted in fractions of a second.

The EHF band portion of the antenna is the critical covert tactical part of the system. The EHF data are not only encrypted, but sent via a narrow beam width with frequency hopping, which prevents signal jamming. The narrow beam width introduces a high level of complexity to the system by forcing the system to very accurately point the dish precisely to link with an inclined geostationary orbiting MILSTAR satellite. Precise navigational and ship’s attitude inputs are needed—as well as a ring laser gyro-based mast motion sensor (MMS) located in the mast. The MMS is used to sense the independent movement of the mast as it is coursing through the water at periscope depth.

The SubHDR antenna mast is the largest communication mast installed on a submarine and measures 21-3/4” diameter, yet it is installed in half the space of other antenna mast systems. The initial design of the SubHDR system to fit in a smaller area drove a number of design decisions with materials and mechanical interfaces.

The closure door mechanism is a hydraulically actuated single door mechanism, which rotates into the sail. A newly developed titanium-alloy mast supports the system. Initially developed by engineers supporting the Ships and Ship Systems (S^3) Product Area's (PA) Structures and Materials Core Equity, this titanium alloy, called Ti-5111, meets 100 ksi minimum yield strength while maintaining toughness and weldability for deep submergence vehicles. This alloy is resistant to stress corrosion cracking, overcoming significant issues present in a seawater environment. Its use reduces the volumetric size and weight of parts, allowing them to fit within the tight submarine sail space constraints, and prevents the SubHDR system from adversely affecting the critical weight/moment envelope on the SSN 688 Class fast attack submarine.

These improvements to submarine communication resulted from 15 years of design, test, material procurement, and installation support by the Carderock Division's Machinery Integration, Communications, and Networking Department, which supports the S^3 PA. Sponsored by the Program Executive Office for C4I and Space (PMW 770) (formerly Space and Naval Warfare Systems Command (SPAWAR PMW 173)), the SubHDR mast effort began in 1990 for SSN 688 Class fast attack submarines, with teaming between the Naval Surface Warfare Center and the Naval Undersea Warfare Center. The SSN 688 SubHDR antenna system design, platform interfaces, and material procurements have been successfully modified for SSN 21 and SSBN 726 Class submarines. Land-based testing of the SSBN 726 design should be wrapped up in late winter 2006.

Since the mid-1990s, engineers from the Machinery Systems Core Equity of the S^3 PA have successfully teamed with Northrop Grumman Newport News Shipbuilding, Naval Undersea Warfare Center, SPAWAR Charleston, Puget Sound Naval Shipyard, and Oceaneering, the first private non-shipyard company certified to accomplish SUBSAFE work, to develop alteration packages, and install the SubHDR masts in the fleet.

Today, more than 88% of the fast attack submarine fleet is enhanced with SubHDR capabilities. To date, 44 SSN 688 Class fast attack submarine installs are complete, as well as all three *Seawolf* (SSN 21) Class platforms. In June 2006, installations will begin on the first of 14 SSBNs. The future promises even greater capability with Advanced EHF satellites, the new Navy Multi-band Terminal (NMT), and the proposed Advance HDR mast, efforts that are being spearheaded by NUWC for the PEO C4I and Space PMW 170 and PMW 770.

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MACHINERY SYSTEMS

LIGHTENING THE LOAD

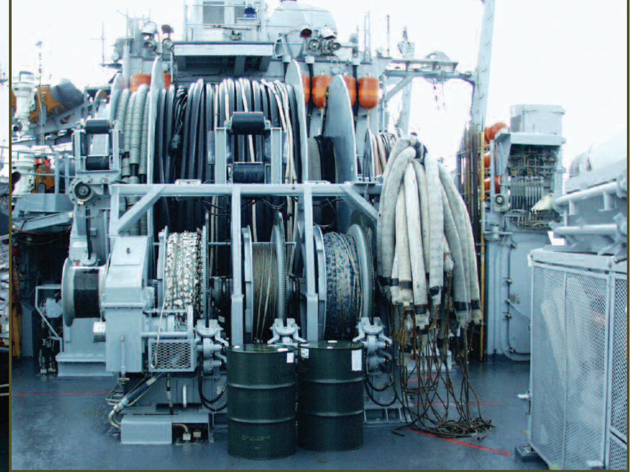
MCM Aft-Deck Redesign Moves Full Steam Ahead

By Christopher Pargola

The aft-deck machinery on the fantail of the *Avenger*, Mine Countermeasures (MCM), class of ships suffers from the effects of deterioration, corrosion, and obsolescence. To combat these concerns and to address a major concern with weight and stability, PEO Ships funded engineers working under the Machinery Systems Core Equity of the Ships and Ship Systems (S^3) Product Area (PA) to redesign this equipment. The effort involves converting the existing hydraulic systems to electric motors and drives—eliminating obsolete parts and reducing the ship's weight. Preliminary studies indicate an estimated reduction of 10,000 pounds or more. This weight decrease will help battle the stability issues currently faced by this class of ship and shows potential for cost savings in reduced maintenance and increased reliability, as well.

LIGHTENING THE LOAD (Continued on page 10)

The aft-deck machinery on the fantail of the ***Avenger***, Mine Countermeasures Class of ships suffers from deterioration, corrosion, and obsolescence. A redesign of the magnetic cable reel, minesweeping winch, and level wind is being undertaken to resolve these problems as well as issues of weight and stability. Shown is the current aft-deck design aboard ***USS Warrior*** (MCM 10).
Official Navy Photo.



The original magnetic cable reel, minesweeping winch, and level wind assembly (shown here aboard ***USS Warrior*** (MCM 10)) are being redesigned. The equipment will be converted from hydraulics to electric motors and variable AC drives.
Official Navy Photo.

LIGHTENING THE LOAD *(Continued from page 9)*

A more prevalent issue associated with this class is the lack of original equipment manufacturer (OEM) support for its hydraulic power unit (HPU), specifically on MCM 1 through 8. The HPU provides hydraulic power to the cable reels and stern cranes. The first of two engineering efforts will focus on redesign of these ships. Once a solid design is established, S^3 engineers will then begin a concurrent design for the MCM 9 through 14. In addition to the main HPU, the magnetic cable reel, minesweeping winch, and level wind assembly must all be converted to electric motors and drives. Furthermore, electric drive technology in conjunction with a programmable logic controller (PLC) will be used to integrate the new systems with the existing Integrated Condition Assessment System (ICAS) configuration. This scheme will display all pertinent information at a central monitoring station. This will allow ship's force to monitor the condition and status of the cable reels and stern cranes. The goal is that the information gathered will lead to a condition-based assessment of the equipment.

Due to the magnitude of this project, the engineers supporting S^3 conducted a comprehensive market survey. In spring 2005, representatives from Carderock Division's Ship Handling and Deck Machinery Systems Branch organized a conference in Ingleside, TX, which is homeport to many minesweepers. They conducted an open forum to present preliminary engineering concepts and redesign ideas. They sought input from technical personnel who have dealt with this equipment for years, as well as the actual end users and deck plate personnel who operate and maintain this equipment. Representatives from the MCM fleet, Naval Surface Warfare Center Panama City, Puget Sound Naval Shipyard, South Central Regional Maintenance Center, and Navy Inventory Control Point participated in an active and informative open discussion. Invaluable information was shared on issues such as redundancy, minesweeping gear use, deployment of floats and deflectors, and fantail space concerns. The forum helped engineers understand all of the fleet requirements and allowed all parties to agree upon any design specifications or changes from the original capabilities of the equipment.

Under the S^3 PA, Carderock Division engineers continue to explore many different avenues for the most effective and efficient redesign of the aft deck equipment on the MCM Class. Plans are underway to conduct follow-up conferences to present actual design ideas and to discuss the performance plans and specifications.

S^3 engineers will take the project from a conceptual design through the preliminary design, and in some cases to the final design phase. The first installation start date is April 2007 on the MCM 4.

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Battery Support for S3

Two Warfare Center Divisions Combine Efforts to Serve the Navy

By William Palmer

Components of the Crane and Carderock Divisions of the Naval Surface Warfare Center are collaborating to provide research and development (R&D) and acquisition/in-service engineering (ISE) support for battery and other electrochemical power system requirements for the Navy. The team is nationally and internationally recognized as a facilitator of technology transfer within government and industry, and is exceptional in its experience in the development of electrochemical technologies for emerging requirements. Working under a memorandum of understanding (MOU) dating back to 1993, the two divisions, with operating locations in Crane, IN, and West Bethesda, MD, dovetail their strengths to provide a balanced program of service, which includes research and development activities performed in Maryland and acquisition and ISE work done in Indiana.

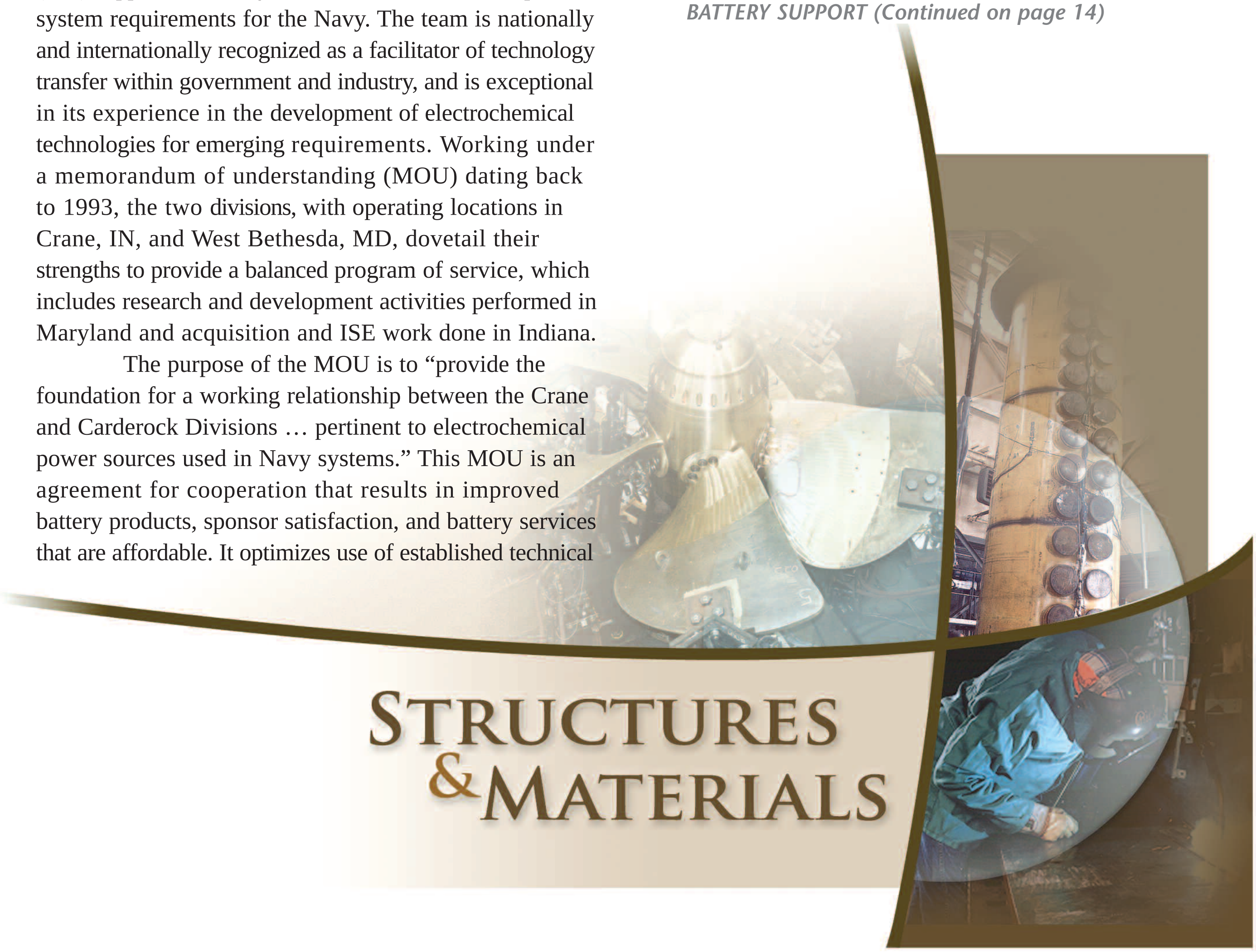
The purpose of the MOU is to "provide the foundation for a working relationship between the Crane and Carderock Divisions … pertinent to electrochemical power sources used in Navy systems." This MOU is an agreement for cooperation that results in improved battery products, sponsor satisfaction, and battery services that are affordable. It optimizes use of established technical

> *"…The different backgrounds, collective experience and processes used by the two Divisions complement and focus the total mission capability into a unified team that provides NSWC capability greater than the sum of the individual Division capabilities."*

competence and efficient use of present resources. It facilitates effective communication, teamwork, and NSWC's continuing leadership in electrochemical power sources.

One of Carderock Division's areas of responsibility is to conduct fundamental materials research and development and involves itself with such endeavors as developing new and innovative materials and system designs, researching high-risk and high-payoffs, and evaluating systems and materials. As the product or

BATTERY SUPPORT (Continued on page 14)



CUSTOMER ADVOCACY

JOINT PROGRAMS

Gaining Efficiency by Maximizing Technical Capabilities Across Joint Services

Photo collage illustrating the vast array of joint services supported by the S^3 Joint Program CA .
Images courtesy of Joint Programs CA Group.

By Ronald Warwick

The NAVSEA Warfare Centers provide scientific and engineering talents and capabilities to meet current and future naval, joint, and national requirements. Future naval warfare will focus on joint expeditionary operations conducted in the forward-deployed environment of the world's littoral regions. To this end, product area directors (PADs) work at the enterprise level to steward needed capabilities within their respective product areas (PAs). This enables the Warfare Centers to provide science and technology, acquisition engineering, in-service engineering, and test and evaluation support to the Navy, Marine Corps, joint programs, and national requirements of today, as well as effectively develop the offensive and defensive capabilities of tomorrow.

Responsible for reaching across geographical boundaries to find innovative ways of introducing synergy, fostering collaboration, and integrating products across the Warfare Centers more efficiently and effectively, the Ships and Ship Systems (S^3) Product Area Director (PAD) established customer advocates. These advocates interface with customers to better understand their needs and develop a unified support approach that brings together technical capabilities spanning multiple divisions, thus increasing the value of the S^3 work to both the customer and the nation.

The joint programs advocates support a vast array of customers from the Navy, Air Force, Marines, Army, Coast Guard, Military Sealift Command, Maritime Administration, Special Operations, Defense Department, National Aeronautic and Space Administration, National Oceanic and Atmospheric Administration, Joint Forces, Office of Force Transformation, and Foreign Military Sales/Transfers. These advocates comb the S^3 and Warfare Center core equities to identify, unite, and sustain the divisions' technical capabilities needed to meet each of their customer's requirements.

For example, they provided the acquisition support experience of Carderock Division to procure sixteen 65-foot small tugs, four 115-ton barge derricks, and the Logistic Support Vessels (LSV) 7 and 8 for the U.S. Army. Under the S^3 PA, Carderock Division provided acquisition, construction, testing, and fielding support on these Army programs. Additionally, working with the Army provided the Navy engineers with a different perspective on how to support the joint customer with technical authority, smart buyer, and solutions to engineering problems, while procuring these types of vessels which are closer to commercial standards than to military ones.

Another program orchestrated by the joint programs customer advocates involved assisting the Army with its LCU 2000. The vessel experienced abnormally high equipment failures on the bow thruster and main engine reduction gears. The customer advocates brought in materials and systems experts from Carderock Division who, in a short period, analyzed the problem and developed cost-effective solutions. The S^3 PAD and the Carderock Division have recently signed and updated a memorandum of agreement (MOA) with the U.S. Army, Combat Support and Combat Service Support, Product Manager—Army Watercraft Systems (AWS). This MOA calls for Carderock Division to provide full-spectrum engineering support to the Army Watercraft Product Manager to include functioning as the Deputy of Technology for the AWS office.

Another great opportunity for value and efficiency the Warfare Center can offer to the Warfighter through its joint programs experience is the support of the Navy's current initiative to reconstitute its brown-water capability in support of the Global War on Terrorism. The Warfare Center employs technical personnel experienced with Vietnam-era Navy riverine craft, as well as recent acquisition and sustainment experience with the USMC and USSOCOM riverine craft, and USN/USCG force protection watercraft. In fulfilling our national commitment, the S^3 PA is planning to bring together and offer a Warfare Center team of experts to satisfy the emerging and critical riverine and harbor security requirements of the newly formed U.S. Navy Expeditionary Combat Command (NECC).

Some of these same experts were recently awarded the NAVSEA Engineer Team of the Year Award for its support of the USMC Small Unit Riverine Craft (SURC). Their efforts resulted in the first military riverine craft with smoke obscurants, night vision imaging system compatibility, reduced acoustic signature, ballistic protection, and camouflage integrated into a craft during production. The craft has become an essential asset for USMC operations supporting Operation Iraqi Freedom. This team's proven capability and commitment to the Warfighter is best demonstrated in a quote from a USMC Commanding Officer of one of the boat squadrons that saw action outside of the Continental United States during the Global War on Terrorism, "… I can say without hesitation that if we hadn't had the SURCs, a number of our Marines would have been wounded or worse over the last 175 days. ..."

Although tied to the S^3 product area, the nature of joint programs support requires these advocates to liaison with the other product areas as well. The majority of joint program customers draw upon the technical capabilities of many Warfare Center resources. To ensure the customers' needs are met, the joint programs customer advocates collaborate with those from other product areas to identify the right athletes/team from the Warfare Center resources to satisfy the requirements. An outstanding example of this is the recent Warfare Center support provided to USSOCOM in the area of human factors engineering on high-speed craft. Upon understanding the customer's requirements, customer advocates from S^3 Joint Programs and the Littoral Warfare Systems Product Area facilitated collaborative meetings with appropriate technical experts from Naval Surface Warfare Center Carderock Division and Panama City to identify the right athletes with the right combination of capabilities to ensure the customer requirements were being met efficiently and effectively. This example highlights our goal of providing one joint Warfare Center proposal to customers whose support requirements are best met by applying resources from multiple Warfare Center sites.

These are transformational practices, which are leading us to develop the right capabilities at the right places to enable us to better serve our customers and our Nation, now and in the future.

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BATTERY SUPPORT (Continued from page 11)

process matures, Crane Division, supplying expertise as an acquisition and ISE agency with technical responsibilities for fleet readiness and product support, determines best practices to acquire and evaluate batteries, and maintains contact with the fleet to support the product prior to and after installation onboard Navy ships. Both organizations use their respective strengths to work with industrial partners to improve manufacturability, quality, safety, efficiency, etc. Funding that supports the team's project work comes from multiple and varied sources, and project work supported by this team can stretch across as many as nine product areas throughout the Warfare Center enterprise.

Factors that drive the direction of the unified team include the areas of autonomous systems and

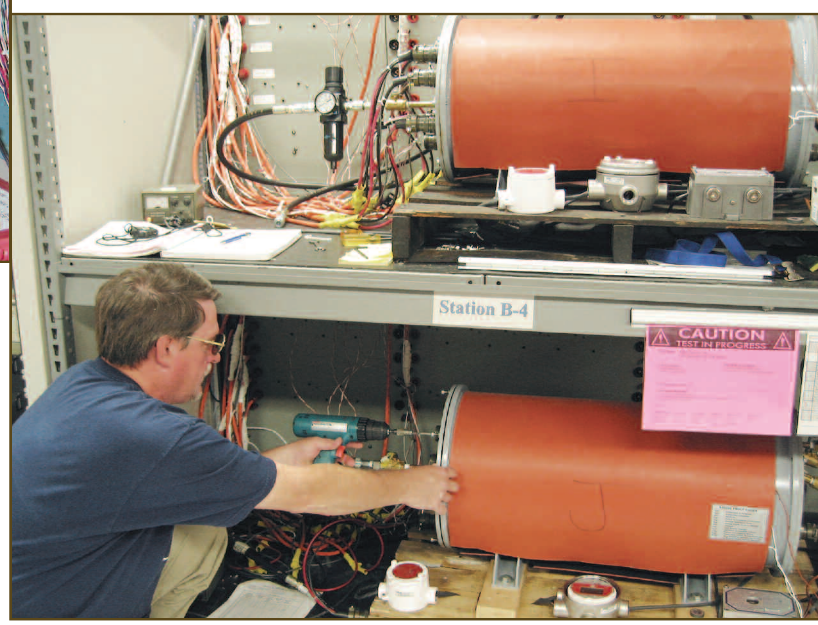
Julie Banner and Clint J. Govar in the NSWC Carderock Abusive Test Facility.
Photo by Pam Lama, NSWC, Carderock Division.

Dave Woolsey assists John Heat in the NSWC Crane Aircraft Lead Acid Laboratory.
Photo courtesy of NSWC, Crane Division.

vehicles, all-electric shipboard propulsion systems, distributed power systems, and many other areas of investigation. One Ships and Ship Systems (S^3) Product Area (PA) project falls in the arena of unmanned vehicles, where multiple mission requirements must be addressed: a "silent watch," or station-keeping reconnaissance signature, ride-through power, a backup power system for onboard electrical loads when the main power system is lost or diverted to other uses, and considerations for full life-cycle and launch platform survivability and vulnerability.

Another long-time team effort is the lithium and lithium-ion battery safety program, where all lithium battery designs are evaluated and certified for safety prior to use on a Navy platform or facility. This is especially relevant with the burgeoning number of stand-alone, high power systems carried by various personnel and units involved in joint operations on the Navy's unique platforms.

The impressive extent to which Crane and Carderock Divisions come together to apply their talent



Allen Ray Fritch configures a test/pressure chamber for testing silver-zinc rechargeable batteries.
Photo courtesy of NSWC, Crane Division.

Hampton Dejarnette in the NSWC Carderock Abusive Test Facility.
Photo by Pam Lama, NSWC, Carderock Division.

to Navy missions is again acknowledged by the MOU: "… The different backgrounds, collective experience and processes used by the two Divisions complement and focus the total mission capability into a unified team that provides NSWC capability greater than the sum of the individual Division capabilities."

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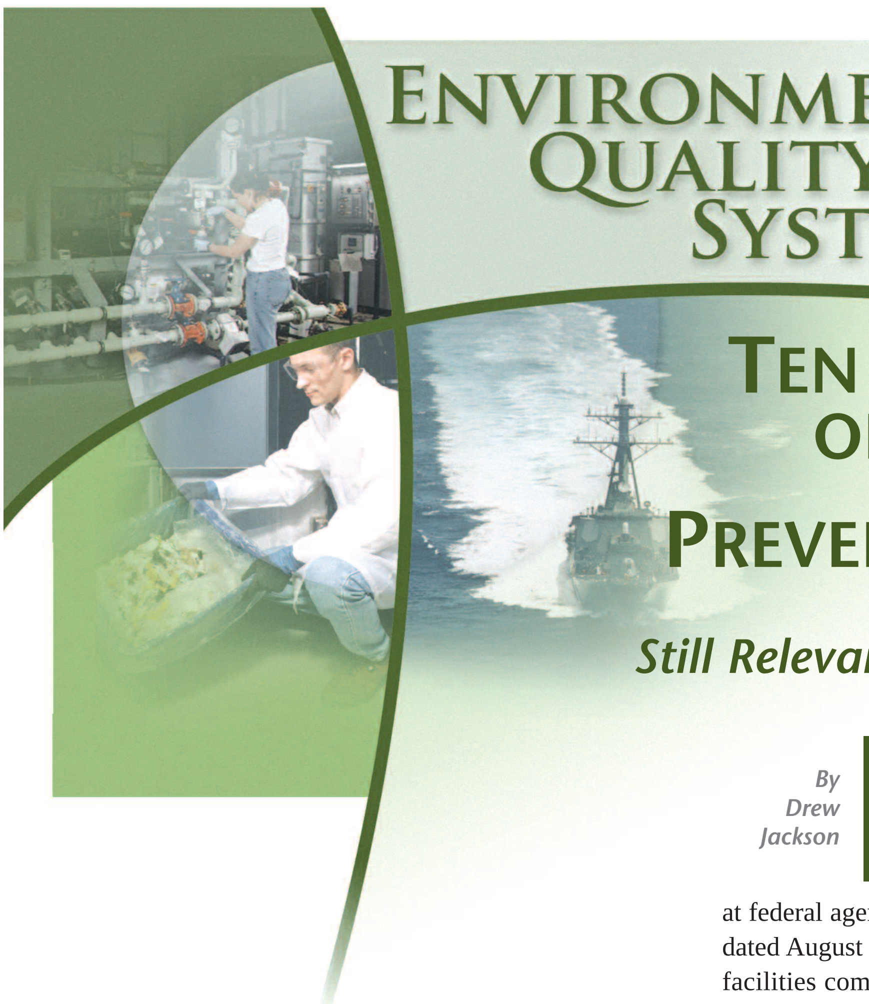

Environmental Quality Systems

Ten Years of Pollution Prevention Afloat

Still Relevant After All These Years

By Drew Jackson

To promote pollution prevention (P2) as a preferred environmental management strategy, President William Clinton issued a series of Executive Orders (EOs) that were specifically directed at federal agencies. Primary among these was EO 12856 dated August 3, 1993. This EO required that all federal facilities comply with the *Emergency Planning and Community Right to Know Act of 1986* and the

POLLUTION PREVENTION (Continued on page 16)

Above and at right, the cable cleaner lubricator provides a semi-automated approach to wire rope cleaning and relubricating maintenance, saving time, labor and material, while improving the health and safety of the Sailors.
Photos by Pollution Prevention Afloat Team.

***POLLUTION PREVENTION** (Continued from page 15)*

Pollution Prevention Act of 1990. It established a goal of 50% reduction in the release and transport of hazardous materials (HM) against a 1995 baseline. On April 21, 2000, EO 13148 reaffirmed and advanced the goals established in the first EO. Both EOs made federal facilities accountable for reducing HM, while establishing P2 as the preferred means to achieving this goal.

Surveys of Navy homeports confirmed that as much as 70% of the HM handled by the Public Works Centers (PWCs) was used, and excess HM offloaded from Navy ships. This important discovery led to the establishment of the Pollution Prevention Afloat (P2A) Program in 1995. Researchers at the Naval Surface Warfare Center, Carderock Division supporting the Ships and Ship Systems (S^3) Product Area's (PA) Environmental Quality Core Equity combined the resources and talents of the ship and shore communities to integrate pollution prevention practices into afloat maintenance processes.

The Pollution Prevention Afloat Program has been a vital component of the Navy's overall environmental compliance strategy for 10 years. Fiscal Year 2005 marked the final year of the P2A Ship Alteration (SHIPALT) Program, which officially began in FY 2000 with the goal of installing 152 surface ships with suites of P2 equipment specifically selected to reduce HM life cycle costs. To date, 145 ships have received ship class tailored suites of up to 18 different P2 equipment types.

Above, the traditional process of shipboard wire rope cleaning is a time-consuming, labor-intensive process, that consumes excess hazardous materials (grease and cleaning solvent), while generating excessive amounts of used hazardous materials (rags) requiring disposal.
Photo by Pollution Prevention Afloat Team.

At right, the pneumatic backpack vacuum, along with the associated pneumatic/ vacuum shrouded paint removal tools provided to the ships as part of the Pollution Prevention Afloat Program's SHIPALT suite of equipment, facilitates the pickup of paint debris during corrosion control evolutions, reducing the potential for inadvertent contamination of the environment.
Photo by Pollution Prevention Afloat Team.

In concert with the NAVSEA and Chief of Naval Operations sponsor's goals of finding and implementing an efficient and effective solution to complying with the requirements of the EO, engineers in the S^3 PA carefully structured a program to identify the sources, processes, and materials that were generating the greatest amounts of used and excess HM aboard surface ships. An efficient and effective structured RDT&E approach was then utilized to survey the commercial sector for existing solutions that would facilitate achieving the desired goal of reducing the Navy's shipboard HM problems. Solutions were sought that would address the problem by process improvement, material elimination or substitution of a less hazardous material for the job at hand, introduction of commercial-off-the-shelf (COTS) solutions employed by industry, and better management practices.

Following the initial surveys, a suite of P2 equipment and management practices was assembled and proposed to a group of test ships for their consideration. A total of nine platforms representing five different classes of ships participated in the tests. Following the test and evaluation (T&E) portion of the program, a careful analysis of the old and new processes was conducted, and a return on investment (ROI) analysis was developed. This ROI analysis resulted in deleting several initiatives due to the lack of a positive return on investment within the program's established goal of a three-year payback period. In other instances, the T&E results led to further re-engineering of the opportunity in concert with the commercial vendor, and then re-testing.

The ships' recommendations resulted in developing standardized suites of P2A equipment, comprised of as many as 18 individual pieces provided in appropriate quantities based upon the ship class, mission, and waste generation rates and with full logistical support. The resultant matrix of ship classes and equipment was developed into a formal P2A SHIPALT Program funded by CNO's Environmental Systems Integration Branch and executed under the technical authority of NAVSEA's Shipboard Environmental Protection Division and the leadership and expertise of the S^3 Environmental Quality Core Equity.

The P2A SHIPALT Program completed its sixth and final budgeted year of installing the identified suites of equipment onboard the surface fleet, from frigates to carriers. This process overlapped into FY06, due to ships' schedule changes. Funding and contracts are in place to ensure completion of all planned ships. To date, 140 of the total 152 planned for installation have been completed.

The Naval Sea Systems Command, in concert with the American Bureau of Shipping (ABS), recently developed Naval Vessel Rules (NVR) to support the design and acquisition of U.S. Navy ships. The continuous improvement goals of EO 13148 and DoD's commitment to P2 as an efficient and effective means to environmental compliance combined with the Navy's newest acquisition tool, NVR, will ensure that the benefits of pollution prevention afloat continue well into the future.

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USS Wasp.
Official Navy Photo.

Vulnerability & Survivability Systems

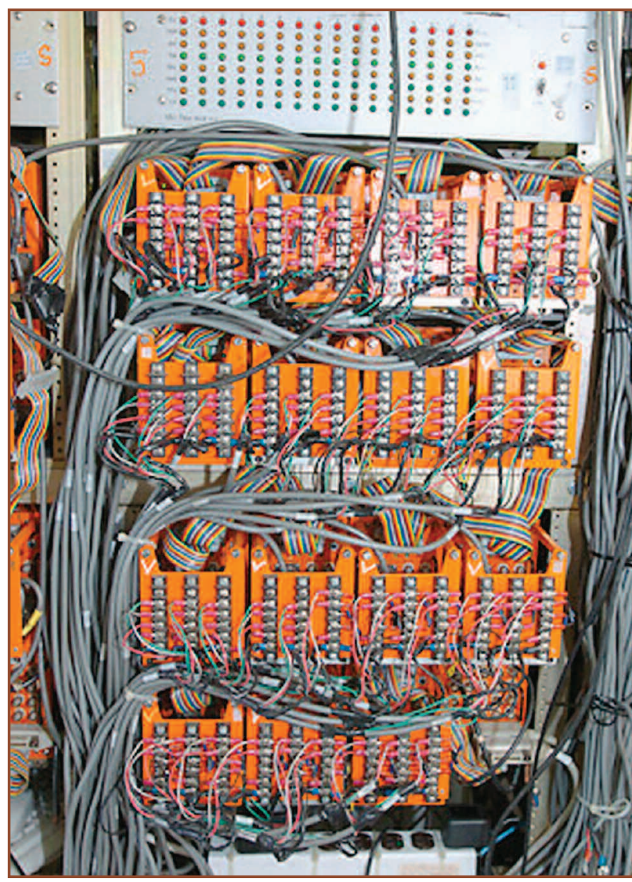
UNDEX Data Acquisition Efforts

Measuring a 150-Foot-Long Model's Response to Blast Energy

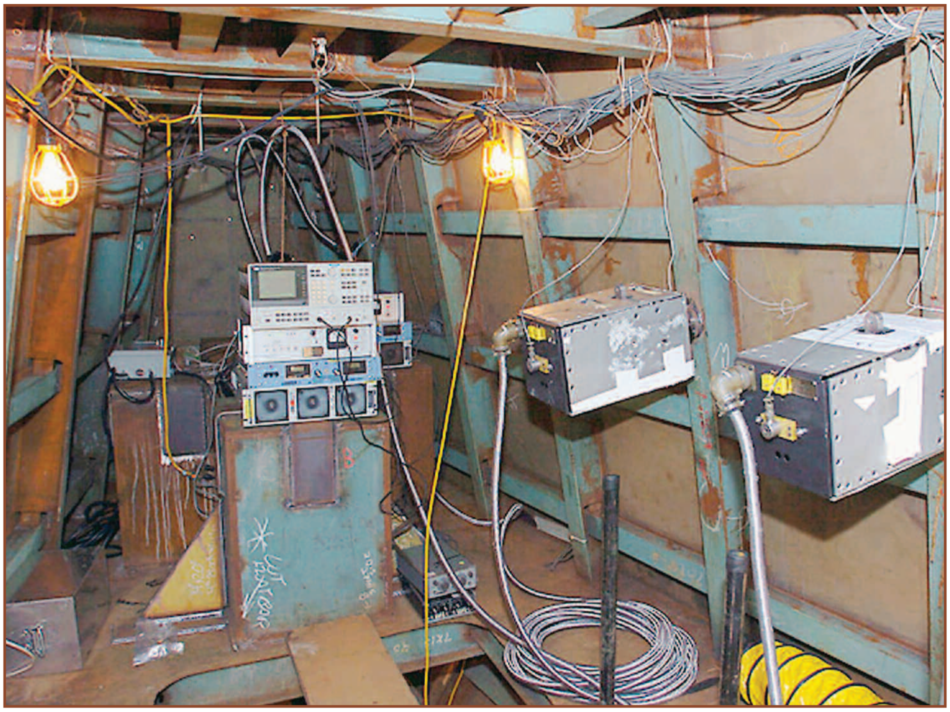
By William Palmer

In a series of underwater explosion (UNDEX) tests conducted between January and April 2005, researchers subjected a quarter-scale model of a ship design to explosive forces to gauge the model's response to that energy. Personnel instrumented a 150-foot-long model with motion and pressure sensors, both to record the UNDEX input levels and to quantify the model's structural response to the explosion events. Engineers then used the data gathered from the tests to improve the correlation between the prediction of a computerized model of the event and the real-world environment.

Ten data runs comprised the total number of events in the schedule, with two runs being conducted per week, at the UNDEX Test Facility at the Aberdeen

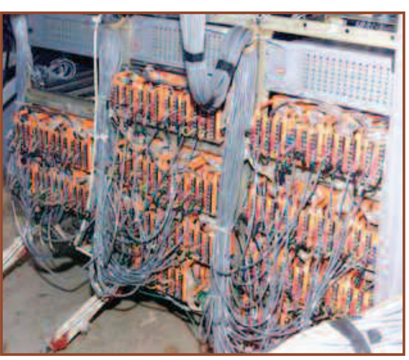


Digital recorder modules installed in rack.
Photos courtesy of Aberdeen Proving Ground.



Shakers mounted on hull.
Photo courtesy of Aberdeen Proving Ground.

Test Center, a tenant activity located on the Army's Aberdeen Proving Grounds. Approximately 150 channels of response gages were installed on the model, including accelerometers, velocity meters, strain gages, and pressure gages. The instrumentation team spent six weeks on site prior to the first test to install and wire the gages. A total of nearly 100,000 feet of cable was run throughout the model. The cable bundle was passed through watertight stuffing tubes in various ship bulkheads and decks, to a floating platform housing the conditioning and recording data acquisition equipment. The data acquisition power and control lines were run from the floating platform to a control station on shore.



Prior to the testing portion of this series, members of the Ships and Ship Systems (S^3) Product Area's (PA) Signatures, Silencing Systems, and Susceptibility Core Equity mounted two 300-pound electro-mechanical shakers to the model's structure to perform a modal characterization. Working in conjunction with the instrumentation team, modal vibration data were recorded. The result imparted vibratory energy to the model's structure, giving engineers a quantitative representation of how the model would react to the UNDEX input. Besides the instrumentation efforts, other teams from the Vulnerability and Survivability Core Equity of S^3 PA participated. Their roles involved ballasting and rigging the model, as well as charge placement and ranging.

This testing regimen will help validate computer models and will enable more refined testing to be performed in the future.

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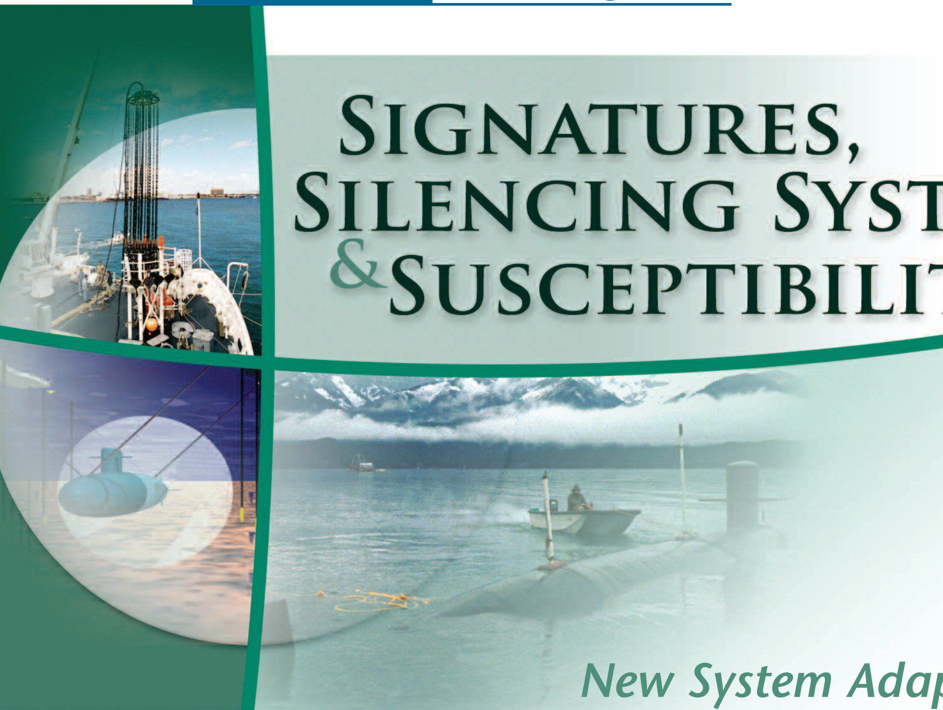


SIGNATURES, SILENCING SYSTEMS, & SUSCEPTIBILITY

SOUTH TOTO ACOUSTIC MEASUREMENT FACILITY

New System Adapts SEAFAC Design; Replaces Shipboard System

By William Palmer

A new acoustic measurement system, called the South TOTO (Tongue of the Ocean) Acoustic Measurement Facility, or STAFAC, is being developed using an existing acoustic measurement system design, the Southeast Alaska Acoustic Measurement Facility (SEAFAC) Upgrade Program, as a template. The new system marks the beginning of a four-year upgrade of Carderock Division's support assets for NAVSEA's full-scale acoustic trials program and as part of the Submarine Acoustical Signature Maintenance Program. Carderock Division personnel supporting the Ships and Ship Systems (S^3) Product Area (PA) and in collaboration with Analysis and Assessment (AA) PA and Newport Division, are developing this upgrade, which is expected to save about $4 million per year in operating and maintenance costs and produce gains in measurement efficiency.

The STAFAC program is the culmination of a joint effort between the Undersea and Surface Warfare Centers that started in 1997, as NAVSEA and the Program Executive Officers were seeking effective alternatives to sustain the *USNS Hayes* (T-AG 195). Innovations in underwater telecom technology inspired a joint study to assess a fixed alternative. The "STAR" Report was published in 2003 and concluded a fixed alternative was feasible, but cost was a limitation. By leveraging the new SEAFAC design, the team was able to modify the approach and reduce the cost to an executable level, resulting in the STAFAC program. The Warfare Centers worked together as technology and installation site partners from the start to ensure that the fixed site's capabilities blend seamlessly with the SEAFAC technology and integrate into the Atlantic Undersea Test and Evaluation Center (AUTEC) infrastructure, thus keeping down acquisition costs and promoting efficient scheduling.

STAFAC will be a bottom-mounted system as opposed to the current system, which is surface deployed from the *USNS Hayes*, an acoustic survey ship used by Carderock Division and operated by the Military Sealift Command. This surface-deployed system is subjected to movement imposed by winds and ocean currents. Also, as a shift in local weather patterns might take several hours to stabilize, the time spent waiting for weather to subside creates inefficiencies in time management during full-scale acoustic trials. The proposed system will be fixed to the ocean bottom and suspended in the water column with a submerged buoy, making the hydrophone arrays less susceptible to ocean currents and increasing the accuracy of acoustic measurements.

Another challenge *Hayes* presents is that she introduces background noise to the acoustic environment, elevating the acoustic noise floor of the immediate area. It takes extra hours of processing time per day to remove Hayes' background noise from the collected data. Despite these disadvantages, the deployment of acoustic measurement systems from *Hayes*, and its predecessor ship *MONOB* (YAG 61) over the last 40 years proved invaluable in the development and refinement of today's complex measurement systems.

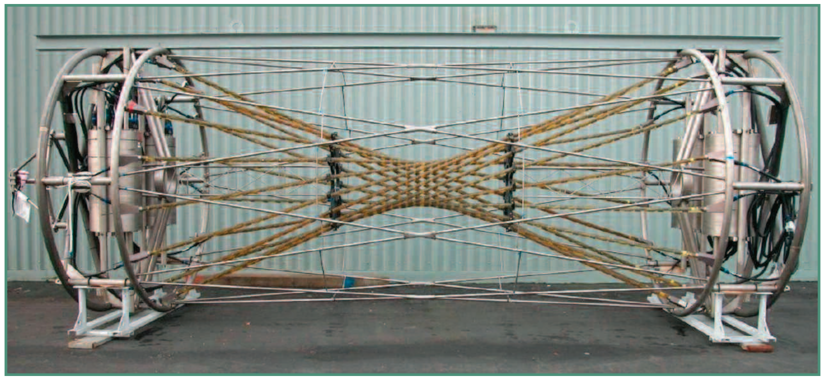
The *Hayes* surface-deployed system utilizes hydrophones arranged in a volumetric array via two

concentric rings of hydrophones, using 640 sensors for mid-frequency coverage. This system was delivered in 1994 and is based on late-1980s technology. STAFAC will utilize the new SEAFAC array design of 640 sensors arranged in a twisted bi-cone configuration to further suppress

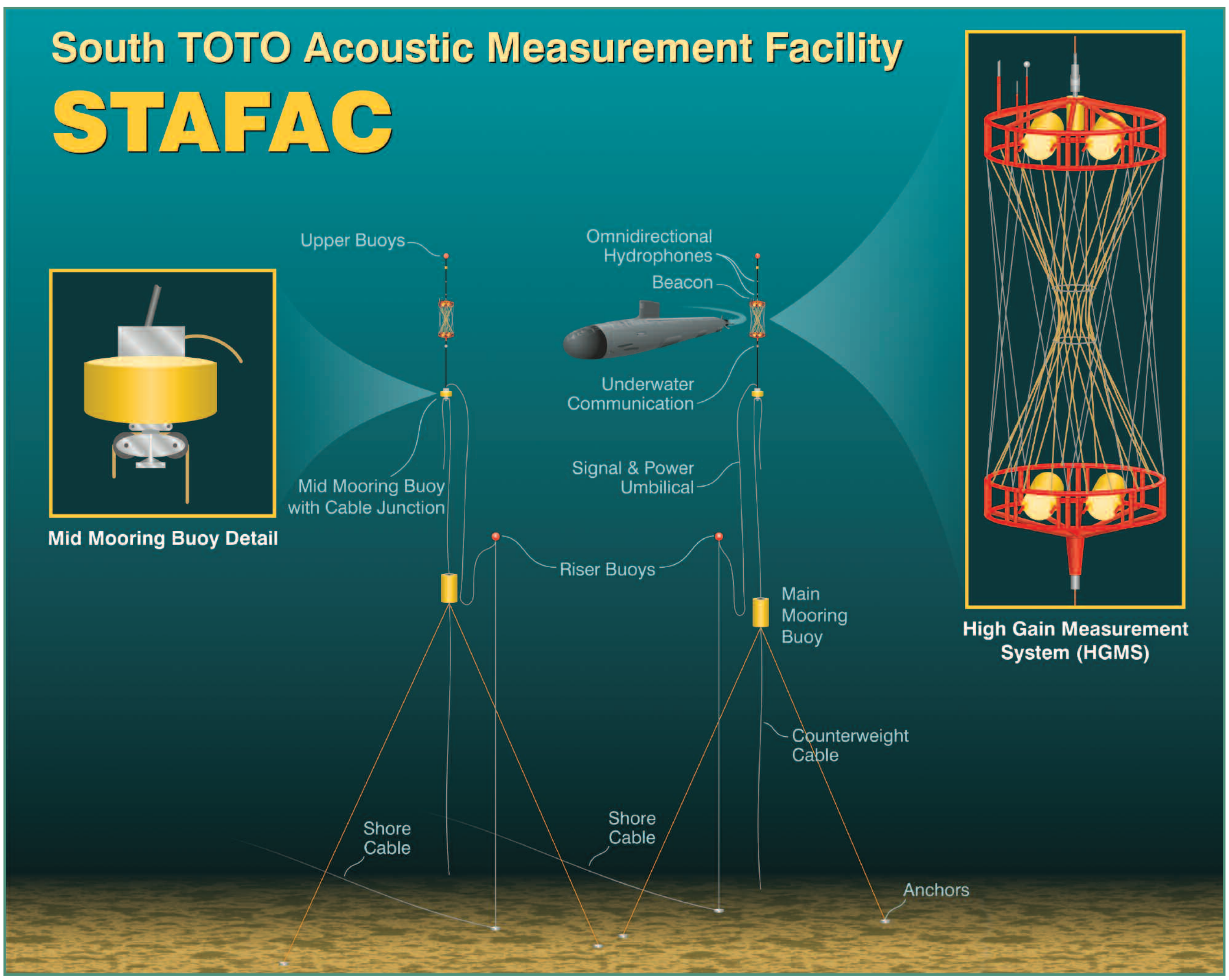
MEASUREMENT FACILITY (Continued on page 22)

Above, a graphic map compared with satellite image of Tongue of the Ocean.
Map by Gary Garvin, NSWC, Carderock Division.

At right, new twisted bi-cone array has 16 staves with 40 hydrophone elements per stave, and 2 instrument pressure vessels mounted on the space frames at each end. Assembly measures 26 feet long by 9 feet in diameter.
Photo courtesy of Carderock Division's Bremerton Detachment.



Below, a rendering of STAFAC ocean field test setup.
Revised rendering by Gary Garvin, NSWC, Carderock Division.



MEASUREMENT FACILITY (Continued from page 21)

side-lobe interference and is designed to use commercial network topology for high bandwidth data telemetry and transport. Utilizing the SEAFAC design will save money in development costs and non-recoverable engineering (NRE) costs since system construction is based on existing commercial-off-the-shelf (COTS) hardware and software already developed for SEAFAC. There will also be savings in integrated logistic support (ILS) costs due to having both East and West Coast systems utilizing the same spares and support personnel.

Hayes is another contributing factor involved in the upgrade. The ship is more than 30 years old, and planners project FY 07 and outyear overhaul costs to approach $9 million to maintain *Hayes* under current U.S. Coast Guard and ABS certification standards.

The incorporation of the SEAFAC attributes into the new South TOTO measurement system, coupled with the retirement of *Hayes*, promises to save the Navy money in signatures maintenance funding, as well as introduce multiple efficiencies into the data collection system used to help make the Navy's submarines the quietest in the world.

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TECHNOLOGY & INNOVATION

UNMANNED SEA SURFACE VEHICLE

Program Improves Efficiency by Designing from the Ground Up

By William Palmer

The Unmanned Sea Surface Vehicle (USSV) project, begun in spring 2003, is helping transition unmanned technology into the Navy and introducing innovation through a "design-for-purpose" approach. In this program, sponsored by the Office of Naval Research, two vehicles have been designed and built to address their respective mission sets. Designers supporting the Ships and Ship Systems (S^3) Product Area (PA) increased the effectiveness of the designs in two ways, first by designing the vessels precisely for the missions they are intended to perform, and second by designing two specific boats which can more effectively address the tasks they are to perform. The S^3 PA tie-in focuses on the overall systems integration and specific vehicle performance characteristics such as speed, endurance, payload capacity, and seakeeping. By building in the required performance characteristics, these semi-autonomous vehicles are able to perform the selected missions.

Carrying appropriate payloads, these vehicles can be deployed for surface strike, mine warfare, and anti-submarine warfare (ASW) missions. They introduce efficiency and effectiveness by addressing the reality that no one vehicle can be optimized for all missions. Accordingly, S^3 PA designers combined performance goals set for the vehicles with increased capabilities to meet mission demands. Maritime Applied Physics Corporation in Baltimore, MD, built the craft. One

of the craft, capable of 35 knots or greater, employs hydrofoils to lift the craft's hull out of the water, providing a stable platform and eliminating wave slap. The other design employs fixed, tunneled propellers to propel the craft to a top speed of 20 knots or greater. The pair of vessels will likely save operating costs, since helicopters are currently used to perform some mission areas for which the vessels are designed. Designers collaborated with personnel from the Littoral Warfare Systems and Undersea Weapons and Vehicles Product Areas to identify and refine important vehicle characteristics.

Most of the components making up these two vehicles are commercially available–another cost reduction feature–although some components, such as

High-speed variant, shown at left, and low-speed variant, shown above, of the USSV design.
Images provided by Will Sokol, NSWC, Combatant Craft Division.

the hydrofoils on the high-speed vehicle, are customized. One of the design challenges addressed in the design of the high-speed craft is the ability to continue operations in sea state 3 and maintain speed. Current small craft of comparable length are unable to accomplish such a feat. Thus, an important driver in this part of the USSV project is to investigate and demonstrate the ability of a small craft to maintain high speed in high sea states.

Both vehicles are designed to accommodate mission requirements associated with the Littoral Combat Ship program, although they are not an integrated component of that effort. The 39-foot, low-speed craft, referred to as a High Tow Force vehicle because of its ability to tow mine warfare and ASW equipment in its wake, has completed in-water testing, while the 35-foot, high-speed craft is in the process of completing its in-water trials. Future developments and demonstrations will include the launch and recovery of these craft from the host platform.

The USSV project is a means by which the Navy will gain experience with the capabilities of unmanned surface vehicles to execute ever-expanding missions while saving costs through design efficiency and operational effectiveness.

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TECHNOLOGY & INNOVATION

Low-Observable Integrated Apertures

Ongoing Research into New Surface Ship LO Antenna Concepts

By William Palmer

The Low-Observable Integrated Apertures Program is rooted in the Advanced Enclosed Mast Sensor system (AEM/S), which demonstrated improved signature and antenna performance characteristics while at sea on *USS Arthur B. Radford* (DD 968). AEMS/S technology uses frequency-selective surfaces that can control the pass-through and reflection of electromagnetic energy at predetermined frequencies. An adapted version of the AEM/S concept and its related

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technologies was used in the design of the new *San Antonio Class* (LPD 17) of amphibious assault ships.

An advanced technology demonstration project, initiated in 1998, took this methodology even farther. The low-observable multi-function stack (LMS) was developed and installed onboard a gas turbine powered Navy ship (*R/V Lauren*). Navy researchers were challenged to develop clean topside architectures that incorporated signature control shapes and materials, treatment for infrared signature sources, and low-observable antennas. This demonstration successfully balanced the need for a low infrared signature (controlling the heat emission of turbine exhaust gases and thereby reducing detectability), low radar cross section (based on a redesigned stack shape) and the integration of several multi-purpose antennas into the stack structure.

Now, researchers supporting the Signatures, Silencing Systems, and Susceptibility Core Equity of the Ships and Ship Systems (S^3) Product Area (PA) assumed a leadership role in a multi-organizational team with members from other government labs, academia, and industry. Each of the team members brings his or her expertise to the aperstructures technology area. The term "aperstructure" refers to the end product which results from the integration of the structure supporting the apertures and the apertures, themselves.

Engineers and scientists are investigating the technologies required to place radar phased array elements, as well as elements for communications antenna arrays, interspersed among each other in a composite structure. Called an aperstructure, this foundation for placement of arrays is a highly-integrated, low-observable structure which can be applied to large shipboard superstructures. This concept promises a number of advantages in terms of reduced weight, improved design efficiency, reduced cost, improved signatures, and greater design flexibility.

Generally speaking, current large phased-array apertures are "cut into" the deckhouse resulting in many large and small holes in the superstructure. These holes create many additional engineering challenges especially with respect to the structures and ship signatures. The additional reinforcements required to make the structure stable are extremely heavy, requiring a support structure to be built around the apertures, adding even more weight and cost to a ship's superstructure. One aperstructure concept places many small, inexpensive, array elements in proximity to each other, reducing both cost and the need for additional structural reinforcement. This approach also lends itself to more effective, low-cost improvements to antenna isolation and signature control.

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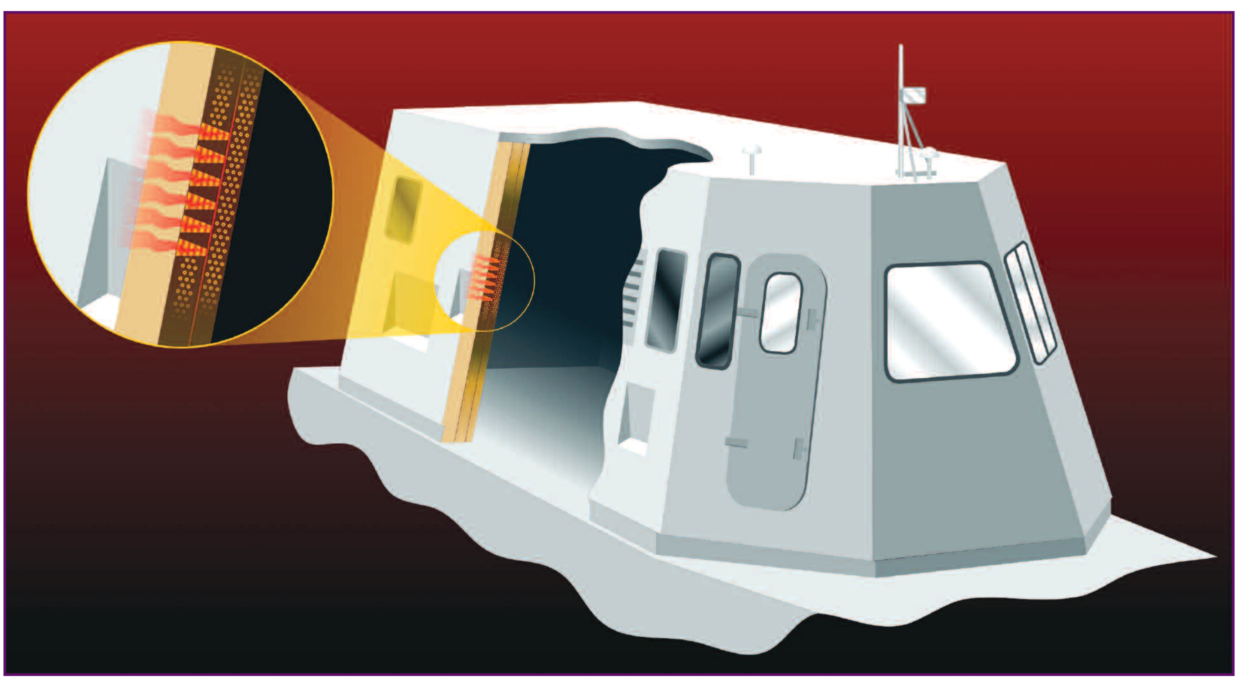
Aperstructure Concept: Depicted is an integrated electromagnetic waveguiding and radiating system embedded within a conceptual deckhouse. The highly integrated structures promises a number of design benefits.
Rendering by Gary Garvin, NSWC, Carderock Division.



Ship Integration & Design

This core equity applies specialized expertise for surface and undersea vehicle design including early concept development, assessment and selection of emerging technologies, integration of selected technologies into optimized total vehicle designs, and evaluation of those technologies and designs for cost, producibility, supportability, and military effectiveness.

Machinery Systems

This core equity provides full-spectrum technical capabilities (facilities and expertise) for research, development, design, shipboard and land-based test and evaluation, acquisition support, in-service engineering, fleet engineering, integrated logistic support and concepts, and overall life-cycle engineering.

Hull Forms & Propulsors

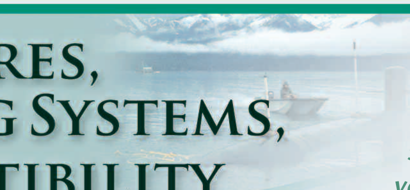
This core equity provides the Navy with full-spectrum hydrodynamic capabilities (facilities and expertise) for research, development, design, analysis, testing, evaluation, acquisition support, and in-service engineering in the area of hull forms and propulsors for the U.S. Navy.

Vulnerability & Survivability Systems

This core equity provides full-spectrum capabilities (facilities and expertise) for research, development, design, testing, acquisition support, and in-service engineering to reduce vulnerability and improve survivability of naval platforms and personnel.

Environmental Quality Systems

This core equity provides facilities and expertise for research, development, design, human systems integration, acquisition support, in-service engineering, fleet support, integrated logistic concepts, and life-cycle management resulting in mission compatible, efficient and cost-effective environmental materials, processes, and systems for fleet and shore activities.



Signatures, Silencing Systems, & Susceptibility

This core equity specializes in research, development, design, testing, acquisition support, fleet guidance and training, and in-service engineering for signatures on ships and ship systems for all current and future Navy ships and seaborne vehicles and their component systems and assigned personnel.

Structures & Materials

This core equity provides the Navy with specialized facilities and expertise for the full spectrum of research, development, design, testing, acquisition support, and in-service engineering in the area of materials and structures.

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